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Students' science process skills under structured and guided inquiry learning condition

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ABSTRACT

Inquiry learning has been known as a popular approach to be studied and applied in science learning. However, the effect of different levels of inquiry on science process skills has not received much attention. This study aims to see the effect of the implementation of guided and structured inquiry on students' Science Process Skills. The quasi-experimental method was carried out with the posttest-only control group Randomized design in two classes of Biology's first-year students. Data were collected with a process skill observation sheet for one semester of lectures. The results showed that both types of inquiry learning showed similar achievement patterns for the types of process skills observed, but generally guided inquiry showed better results. The average score of science process skills in structured inquiry classes was 71.67, while in guided inquiry classes was 78.06. Another interesting finding is that the two types of inquiry learning produce similar performance patterns for the type of process skills observed. The sequence of the type of process skills that are most mastered in both classes is to observe, conclude, classify and communicate. Inquiry learning is able to develop science process skills well, but differences in learning experiences that are more open to guided inquiry are thought to be an explanation of the difference in achievement of process skills between the two types of inquiry.

Introduction

The characteristic of studying natural science is trying to explore the symptoms and life processes of the environment. Biology, as part of science, in its learning, cannot be separated from the nature of science as a product and process. Based on the constructivism learning theory, learning is an activity of building knowledge carried out by students themselves through learning activities that encourage students to be mentally and behaviorally active (Cakir, 2008). Science learning is shaped by experience, by the sequence of experiences, and by thoughtful guidance directed towards learning objectives (Duschl, 2008). Science learning with the characteristics of constructivism is then widely known as inquiry learning (Minner, Levy, & Century, 2010). Therefore, in learning biology, process skills take an important and inseparable part of learning activities.

Empirically inquiry activities support the development of science process skills (Adnyana & Citrawathi, 2017; Damopolii, Yohanita, Nurhidaya, & Murtijani, 2018; Koksal & Berberoglu, 2014). Process skills involve cognitive, manual, and social skills. Cognitive or mental skills involved because by doing the process skills, students use their minds. Manual skills are involved in the skills of using tools and materials, measuring, constructing, or assembling tools. Whereas social skills emerge when students interact and communicate with each other, for example, discussing observations (Rustaman, 2007). Inquiry learning, in accordance with the characteristics of constructivism, gives students experience in all three aspects.

The need for a science learning design designed with an inquiry approach has been emphasized in various kinds of literature (Damopolii et al., 2018; Koksal & Berberoglu, 2014; Lord & Orkwiszewski, 2006; National Research Council, 2000). The Higher Education Institution of Education (LPTK) produces science teachers who teach in schools, so prospective teacher students also need to experience and develop science process skills. Since 2016, State University of Medan has begun to implement curriculum based on the Indonesian National Qualification Framework (KKNI), where there is a change in curriculum structure that integrates theoretical courses with practicum, such as in Plant Morphology courses. This course studies morphological characteristics and types of roots, stems, leaves, flowers, and various modifications. This course requires the ability of science processes (KPS) such as observing, grouping, and communication that really requires students' direct experience in exploration and investigation.

Inquiry learning, in its application, there are several levels depending on how far the teacher is involved in its implementation (Germann, Haskins, & Auls, 1996). Inquiry-based learning varies in the amount of autonomy given to students and covers a broad spectrum of approaches, ranging from structured questions that are directed and guided by teachers to open questions that are self-formulated by students (National Research Council, 2000). Sadeh and Zion (2012) define that in structured inquiry, students investigate questions that are formulated by the teacher through prescribed procedures. At a more complex level, guided inquiry, students investigate questions and procedures formulated by the teacher and then determine the process and conclusions. In an open inquiry, the most complex level of inquiry, the teacher defines the knowledge framework in which the investigation is conducted, but students formulate various questions and determine how the questions will be answered.

Although there is a lot of empirical literature comparing the approach of inquiry with the approach that is not inquiry-based, there are only a few studies that focus on differences between the various levels of inquiry (Bunterm et al., 2014). The types of inquiry that are more relevant to teaching and learning facilities available in schools remain controversial among educators. Jiang and McComas (2015) argue that middle-level inquiry is better at supporting the achievement of science learning outcomes, while higher levels are able to support better scientific attitudes. Some teachers prefer to use structured or guided inquiry, while others prefer to use open inquiry (Zion & Mendelovici, 2012). The effect of differences in the level of inquiry in science process skills has not been given much attention.

Method

This study uses a randomized posttest-only control group design. In this design, subjects taken from the population are grouped into two groups: the treatment group and the control group. The population of this research is two-semester students of the Biology Study Program. Sampling was carried out in total sampling, with one class applying guided inquiry learning as a treatment class and another class applying structured inquiry as a control. The number of students in the treatment class was 33 people, and in the control class were 31 people.

Data on students' science process skills were obtained by performance evaluation techniques using KPS observation instruments. In this study, the types of skills observed were limited to observing, classifying, concluding, and communicating skills. The data analysis technique for science process skills is to compare KPS scores from control and treatment classes. Then a hypothesis test is performed to determine whether the average PPP scores of the two treatment groups are statistically significantly different. Before conducting the hypothesis test, the prerequisite tests for normality and homogeneity of the data are first carried out.

Results and Discussion

This research focuses on the basic skills that are most likely to be observed individually in learning activities undertaken by students. KPS measurement is carried out by an observation technique during the lecture in order to obtain authentic information.

The average KPS score in the control class was 71.67, while the average KPS score in the treatment class was slightly higher, reaching 78.06. The results of the KPS in both sample classes conducted during the plant morphology process are presented in Figure 1.

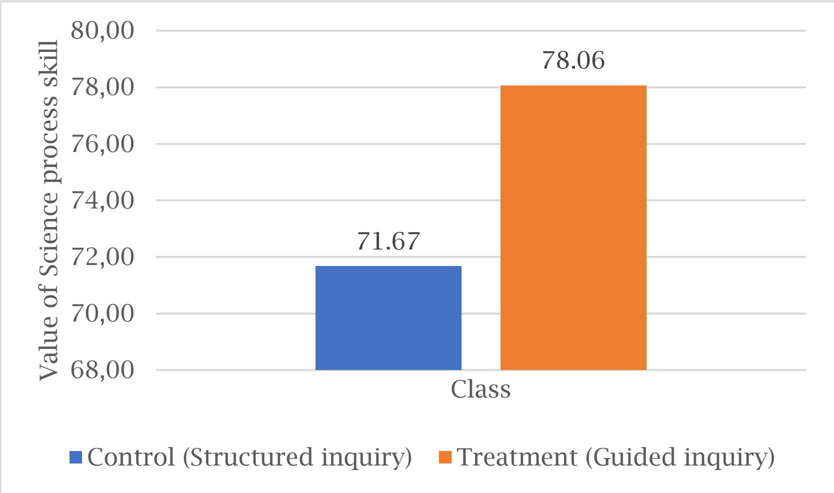

Figure 1.The average KPS final score in the sample class

Figure 1, it can be seen that there are differences in the average KPS from the control and treatment class. A score of 71.67 in the control class is included in the adequate category, while a score of 78.06 from the experimental class has a good category. Therefore, it can be said that descriptively the science process skills of students in the treatment class are better than the control class.

Further analysis of the type of process skills students have in the treatment class shows varying scores between types of KPS. The highest score reached 86.11 in observing skills, and the lowest score was 70.71 in communication skills. Complete results for the score of each type of KPS observed are presented in Figure 2.

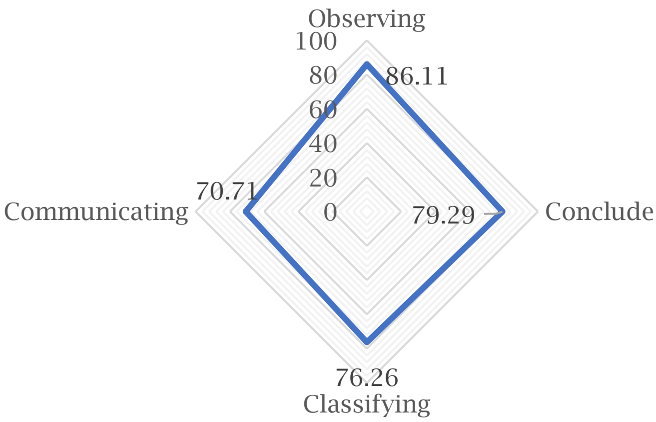

Figure 2.The average score for each type of KPS guided inquiry

Differences in scores between types of PPP also occur in the control class. However, the order of the KPS score in the control class students had the same pattern as the treatment class. The highest student skills of 83.06 are in the observing category, and the lowest is 60.75 in the communicating category. The full results are presented in Figure 3.

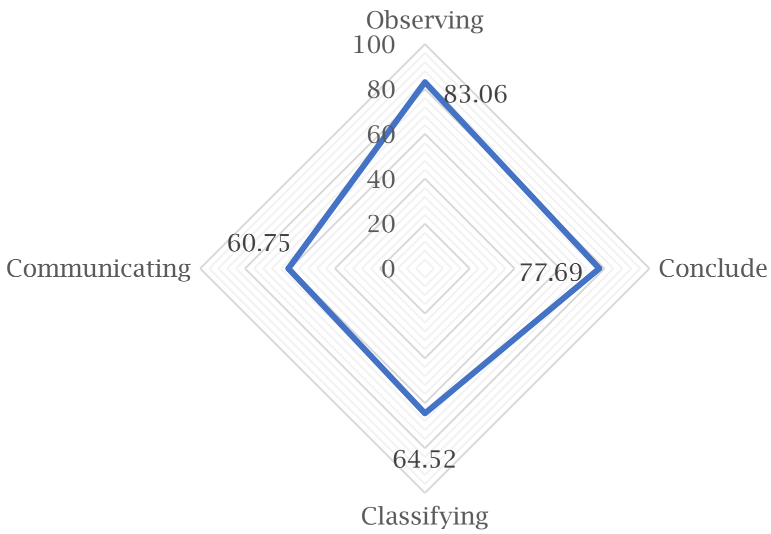

Figure 3.The average score for each type of PPP is structured inquiry class

Before testing the hypothesis, the prerequisite tests are normality and homogeneity. From the normality test using SPSS 16, it was obtained that the data of students' science process skills in both sample classes were normally distributed, indicated by a significance value of 0.522 > 0.05. The results of the data homogeneity test can be seen that the significance value of 0.004 < 0.05, which means the data have a variance that is not the same or not homogeneous. Based on the results of these prerequisite tests, hypothesis testing is carried out with non-parametric statistics.

Descriptive data processing results on the average post-test of the two sample classes showed differences, where the treatment class had a higher average score. In the next step, it is necessary to test the significance of the different average PPPs of the two sample classes to find out whether there are significant differences or not. The test was carried out using the Mann Whitney Test using the SPSS 16.0 program.

Table 1.Test results of significance of postgraduate kps student differences treatment and control classes

		Z	Statistic test Asymp. Sig. (2-tailed)
Score_KPS	Treatment Control	-4.734	0,000

Based on Table 1 in the Statistics Test column, it can be seen that the Asymp value. Sig, which is equal to 0,000 < α (0.05), so it can be said that the two classes have different variants, then Ho is rejected, and Ha is accepted, in the example there is a significant difference between the KPS scores of the treatment class and control class students. This shows that the PPP in the treatment class is indeed higher than the control class. These results are consistent with findings from Sadeh and Zion (2009) and show that the guided inquiry approach is more effective than the structured inquiry approach in providing science process skills.

Inquiry learning represents the processes that scientists routinely use in their research and provides methods for students to learn content and science process skills (Sadeh & Zion, 2012). In other words, in inquiry learning, students are invited to search for concepts through activities that involve questions, inferences, predictions, communicate, interpretations and conclude so that the activities contained at each step of learning in inquiry involve students in the scientific process (Rustaman, 2005). Then the more complex levels of inquiry applied in learning will increasingly develop the components of science skills.

Based on the data obtained (Figure 1), the average score of the treatment class KPS was 78.06, and the control class score was 71.67 include the good category. Furthermore, in each type of student KPS (Figure 4), the treatment class also obtained a higher score than the control class. However, descriptively, the scores for each type of PPP in the two sample classes have the same pattern tendency. Where in both classes, KPS achievements from highest to lowest have a sequence, namely (1) observing, (2) inference/conclude, (3) classifying, and (4) communicating. It is interesting to do further research on whether the pattern is generally accepted, how the pattern can be formed, and its relationship with thinking skills.

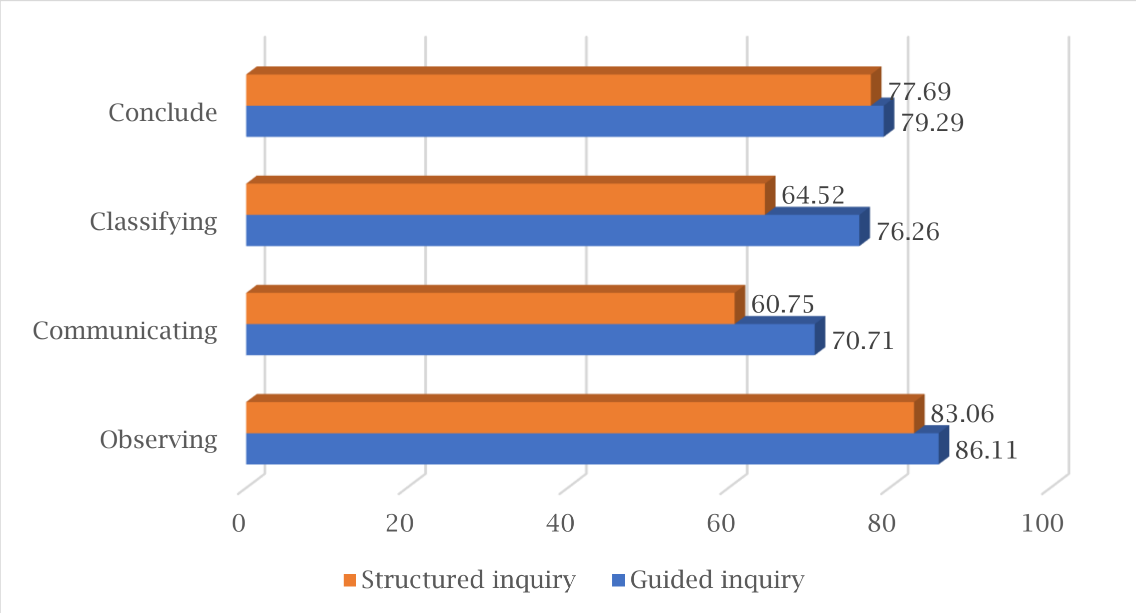

Figure 4. Comparison of the achievement of KPS scores in guided and structured classes

Referring to the interpretation of the range of values, according to Arikunto (2013), both in the treatment and control classes, observing skills have a very good category, while other types of skills are categorized as good. A comparative analysis of the scores of each KPS in the treatment class and the control class was also carried out to get deeper results. Table 2 shows the results of the analysis of the significance of the different scores of each type of PPP from the control class and treatment class.

Table 2. Test results significance of the differences in the scores of each KPS on treatment and control classes

Type of KPS	Std. Deviation	t	Sig. (2-tailed)	Anotation
Conclude	11,80	-0,63	0,53	No significant difference
Classifying	10,93	-6,03	0,00	Significantly different
Communicate	13,51	-4,09	0,00	Significantly different
Observe	10,44	-1,57	0,13	No significant difference

Based on the test results of the significance of the differences in each type of KPS, it is known that two of the four KPS measured have significant differences (Table 2). Classification and communication skills in learning using guided inquiry are significantly higher than structured inquiry. The skills of observing and concluding in both learning are not statistically different. Significant differences in classifying and communication skills can be formed based on the different learning experience characteristics of the two types of inquiry.

In the guided inquiry, to find answers to agreed scientific questions, the learning process is designed so that students determine the tools and materials that can be used and consult with the lecturer. While in structured inquiry learning, the material and sequence of activities are standard, students only need to carry out more evident activities -this difference in learning experience trains classification skills better in guided inquiry classes. Specific experiences, such as classifying appropriate tools and materials, grouping observational data into appropriate categories based on self-designed data recording models, are not experienced by structured inquiry classes.

Various studies, in general, show that inquiry learning has a positive impact on the formation of science process skills (Ergül et al., 2011; Şimşek & Kabapınar, 2010). Higher process skills scores in the treatment class can be caused by students being more trained and accustomed to discovering concepts and facts themselves through more open inquiry learning schemes. Inquiry activities that are more open to emphasize process skills and can reflect the character of science more accurately (Padilla, 1980; Sadeh & Zion, 2009). In other words, to implement the learning that can develop student KPS requires an inquiry learning design that provides a greater portion of student involvement.

Conclusion

Based on the data and data analysis carried out, it can be concluded that the application of guided inquiry learning produces science process skills that are higher than structured inquiry significantly. The type of science process skills most mastered by students is observing skills. Furthermore, succession is followed by concluding, classification, and communication skills.

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